Confidence in data recorded with land seismic recorders

Nicolas Tellier, Jean-Jacques Postel and Steve Wilcox, Sercel, France*

Corresponding author: nicolas.tellier@sercel.com

Keywords

Land, seismic acquisition, recording systems, cross-technology, wireless, quality control

Summary

Three types of land seismic recorder – cabled, wireless and cross-technology – have been used widely in land seismic projects in recent years. At the same time, the concept of Quality Control has continued to evolve, and although field equipment has become highly reliable, there is considerable variation in the QC capabilities of recorders. QC may be acquired in real-time, it may be acquired in-field requiring some additional effort, or there may be no QC acquired at all during acquisition. In addition, increasing operator requirements for denser field configurations and higher productivities are producing larger volumes of daily-acquired data, and checking consistency and suitability for seismic imaging has necessitated new ways of approaching in-field Quality Control. We review herein the main families of land recorders currently available, their QC capability in terms of information and availability, and how QC collection is managed in practice in the field.

Introduction

Land recorders have undergone considerable evolution over the past years, and with the exception of a few attempts to design radio-based recorders in the 1980's (e.g., Tims 1983), only cabled recorders were available until the early 2000's when wireless recorders based on Wi-Fi transmission were introduced. More recently the first cross-technology recorders were released: they blend features of cabled and wireless technologies in a single system in order to best address identified field challenges. These two new types of recorders have dramatically changed the way in which field operations are managed, whether it is crew organization, staff duties, or the quality control of the equipment or seismic data acquired. Meanwhile, the current trough in oil prices and seismic activity has made high productivity acquisition a major price differentiator for geophysical contractors. Although wireless and cross-technology recorders have brought the promise of increased productivity (e.g. by avoiding delays due to cable cuts), operators nevertheless expect to maintain data quality alongside these productivity gains.

The concept of Quality Control has also evolved in recent years, as requirements for higher resolution and improved subsurface imaging (through denser acquisition designs and higher productivity) make traditional Quality Control methods unsuitable. A visual check of every shot is progressively being replaced by statistical analyses based on groups of shots or correlated to the local topography, and on some projects new analysis tools such as in-field real-time PSTM, updated at every shot, help to validate the acquisition parameters (Cotton, 2016). In addition, recorders have reached a high level of reliability and their QC is now more a matter of functionality test (battery level, GPS, geophones connected with proper tilt) than field equipment failure detection. Furthermore, the definition of the term "Quality Control" now differs according to the type of recorder used, and while for cabled systems it covers both seismic data and equipment, for wireless recorders it is generally restricted to equipment, sometimes with the inclusion of field noise. In this paper, we propose to review the main families of land recorders currently available, and how they address the Quality Control issue.

Land recorder families and QC management

Cabled recorders

A major benefit of cabled systems is the level of confidence in the seismic data recorded that they provide, thanks to the availability of data and QC in real-time enabled by their centralized architecture (figure 1a). The trade-off for this confidence is their susceptibility to line cuts. This is becoming more critical as channel densities increase and rising channel counts amplify exposure to line cuts, but also where productivity is key to competitiveness. These factors have come very strongly into focus in the current context of very low acquisition prices and strong competition.

Wireless recorders

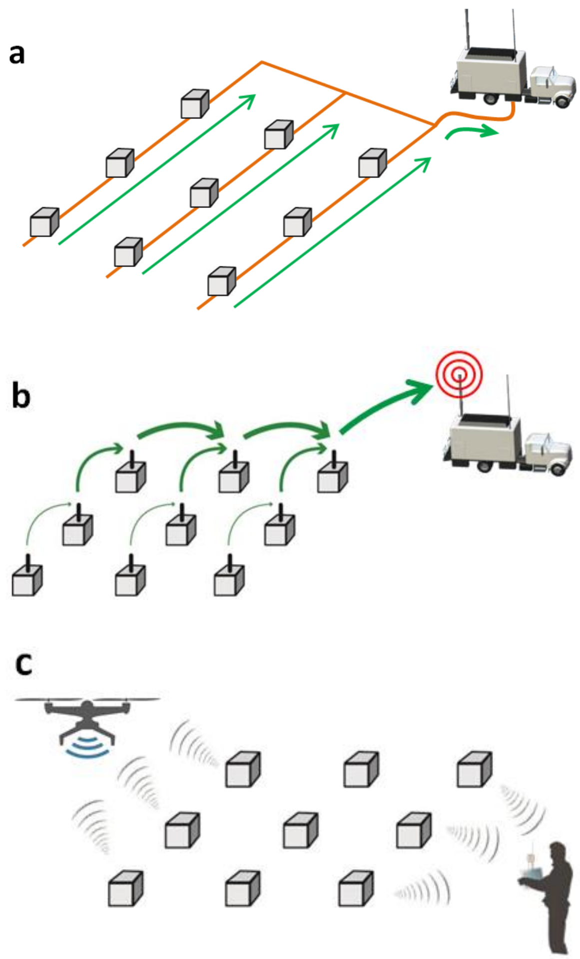
Three families of wireless recorders can be identified, differentiated by their QC capability:

- Real-time wireless recorders are able to automatically transmit equipment QC and field noise with a reasonably short latency (figure 1b). Seismic data real-time transmission still has limited outlets, perhaps due to prior field preparation, equipment cost and limited autonomy that still outweigh the operational benefits for most types of programs.
- QC Capable wireless systems (figure 1c) enable the collection of equipment QC (and to a lesser extent, of seismic data) during acquisition, with some field effort, detailed in the following section.
- Blind recorders, where no QC (seismic or equipment) is available until field nodes are collected and downloaded. This is usually performed at the base camp when recharging batteries (figure 1d). The main benefit of the absence of embedded QC capability is a large battery autonomy. This type of recorder has mainly been used for proprietary programs in North America, or speculative programs where the low acquisition cost overrides quality concerns. Currently, they are not the preferred option for operators, mainly because of the resultant increased operational risk, but they remain in use and successful projects have been demonstrated (e.g., Uribe, 2016).

Wireless recorders are now well accepted, and even considered as mandatory for projects with significant access issues. However, it has to be noted that all types of wireless recorders require a large quantity of batteries (one per channel instead of one per segment – a segment being a group of channels), which complicates field logistics (in the case of external batteries), and their maintenance and eventual replacement increases equipment cost of ownership as the average lifetime of batteries is far below that of electronics.

Cross-technology recorders

The last family of recorders is a relatively recent arrival. It integrates both cabled and wireless system concepts into a nodal architecture, and "intelligence" and memory in field units enable these recorders to operate either as a cabled system, or in an autonomous manner for lines that are isolated through layout or due to line breaks. This architecture easily facilitates the integration of wireless channels into the spread. QC is retrieved accordingly, that is, through the line in real-time for channels connected by cable to the central unit, and as a QC capable or real-time wireless system for autonomous channels and wireless channels (figure 1e). QC of channels temporarily operating autonomously (e.g., due to line cuts) can be retrieved either in the field, or by (re)connecting the line to the central unit.



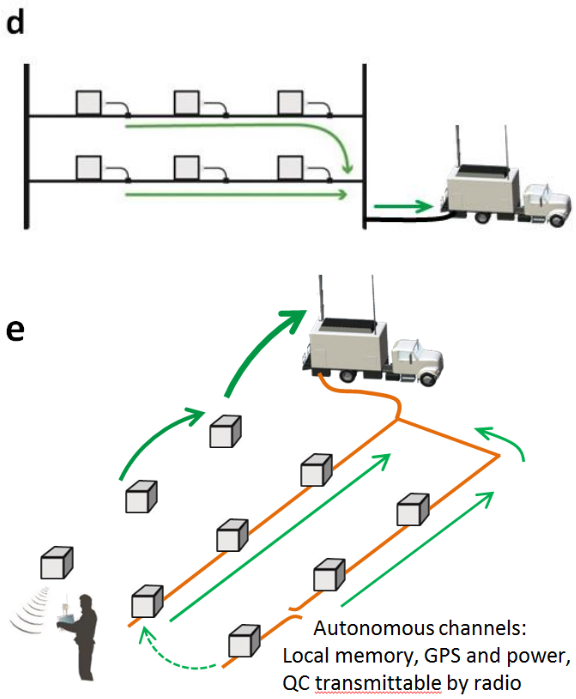


Figure 1: simplified schemes of QC capabilities of the main types of recorders: (a) cable recorders have a centralized QC flow, as (b) real-time wireless recorders that may include or not the transmission of seismic data in near real-time, (c) QC capable wireless recorders: data and QC can be harvested on the field, (d) blind wireless recorders: QC available only through physical connection after modules are retrieved from the field, and (e) cross-technology recorders mixes the possibilities of (a), (b) and (c) and integrate a local memory to address line cuts.

In the following section, the most common methods of QC collection used in QC capable recorders are described, in order to illustrate the flexibility of this approach.

Applications of QC capable wireless systems

Different approaches are being taken by users of QC capable wireless recorder to collect the QC in the field. The two first methods described below apply also to autonomous/wireless segments of cross-technology recorders.

The use of dedicated QC teams using mobile harvesters (Wilcox, 2013) appears to be the most widespread to date. The primary reason for this is the flexibility this approach offers in its ability to adapt the number, size and transportation means of QC teams to the field constraints (principally the topography, distances to cover and permitting). Baris et al. (2014) described an 8,500 active channel survey in France in an agricultural area with difficult access, where approximately 50 % of the deployed channels were checked daily by teams operating on foot. Light vehicles are also commonly used, as are, to a lesser extent, boats and helicopters (figure 2).

Figure 2: dedicated teams on a QC capable wireless spread: walking, with drones, using light vehicles or dedicated boats.

Land recorders and Quality Control

A promising technique to achieve cheaper, more effective dedicated teams is the use of drones. Due to the interest of numerous industries in this technology, drone performance has improved rapidly (in particular their flight autonomy and payload) while local regulations are becoming progressively more flexible. The size and weight of harvesters has dramatically decreased in the meantime, with new devices being around ten times lighter than the 2 kg first generation harvesters, allowing QC by drone to be driven by drone flight autonomy rather than harvester weight. Numerous contractors are already testing this technique (Wilcox, 2015) and drones are already used as a standard QC tool on several commercial projects, allowing the harvesting of 2k - 3k channel spreads twice a day.

The reduction of harvester weight, cost and power consumption opens a new method of harvesting QC – by equipping field staff and vehicles operating within the spread with such devices, harvesting can be performed opportunistically as a background task (figure 3a). Although all channels wouldn't be harvested systematically, it nevertheless allows the collection of information from a large part of the spread with no field effort and with minimal expense. This solution is not currently utilized, but it seems likely to be taken up in the near future, at least as a complement to the other methods described.

There are two other solutions which enable the collection of equipment QC and seismic data in real-time, but on a limited portion of the spread. One or more antennas can be set up on the prospect to establish a real-time wireless connection between channels within range of the antenna(s) (typically 1000m) and the system server (figure 3b). Alternatively, some contractors simply chose to deploy one or two lines of cable channels among their wireless spread (figure 3c).

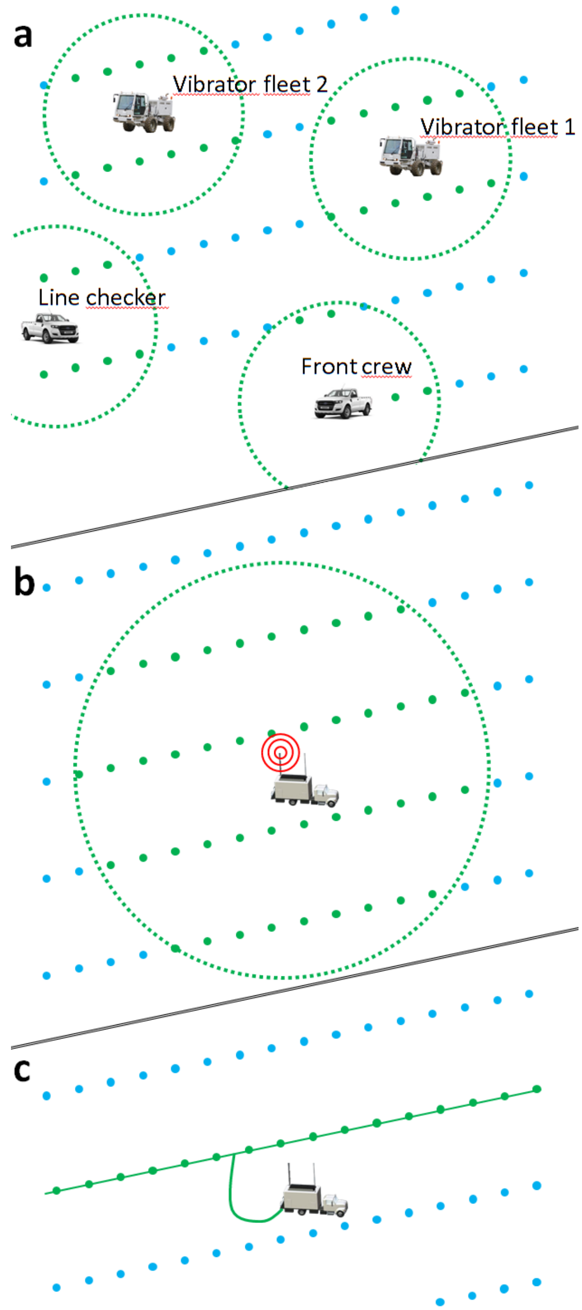


Figure 3: (a) opportunistic harvesting, (b) equipment and seismic data QC around recorder. Extra antennas (not represented) can be installed. (c) a wireless spread complemented by a cabled line. Channels harvested are displayed in green. For (b) and (c), data and QC are available in real-time. Note that spread proportions and distances are not respected.

The use of dedicated teams currently remains the preferred option for its flexibility, and the ability to more closely monitor the most exposed areas (i.e., subject to traffic or exposed to wind). Although this method is best suited to the collection of equipment QC, seismic data can also be collected for small configurations without significant field effort. Experience has shown, however, that as their confidence in such systems and type of operation grows, most users progressively reduce seismic data harvesting during acquisition and undertake it only during channel roll.

Conclusion and discussion

With increasing requirements for denser geometries and higher productivity, the way in which QC is performed is evolving towards statistical approaches, regardless of the type of land recorder used. It remains important, however, for most O&G operators to have access to a minimum of QC within a reasonable amount of time in order to check the equipment condition and monitor field noise.

Full QC (seismic data and equipment) is available in real-time in cabled recorders, while real-time wireless recorders offer equipment QC and field noise in near real-time, sometimes with the inclusion of seismic data. Cross-technology recorders address most of the QC issues in real-time, with only QC collection of wireless parts of the spread being managed as for real-time wireless systems. These three types of recorders thus offer a great confidence in the seismic data recorded.

The approach is however different for QC capable wireless recorders, which represent currently the most widespread wireless option in the field. For these recorders, the use of dedicated teams remains the most popular solution to field QC collection, though significant progress is expected from the use of drones, enabled by technology improvements and more flexible regulations.

While the wireless real-time transmission of seismic data remains currently limited by the existing technologies (in particular in terms of communication rate and autonomy) integrated by equipment manufacturer in their systems, the industry is progressively getting closer to what appears as the ideal answer to user expectations: a low-power wireless field equipment, able to transmit equipment QC as well as seismic data in real-time for subsequent QC, without any need for additional infrastructure or field preparation.

References

Baris S., N. Badel, H. Ribeiro, F. Layan, P. Herrmann, O. Lamerain, A. Jacques and P. Faure, 2014, Allowing Seismic Surveys to Boldly Go Where No Surveys Have Gone Before: 76th EAGE Conference & Exhibition, extended abstract

Cotton J., M. Beilles, S. Mahrooqi, J. Porter, M. Denis, S. Baris, E. Forgues and H. Chauris, 2016, Automated and Real-time Field PSTM - How to QC More Efficiently 10 Billion Traces Today and More Tomorrow: 78th EAGE conference and exhibition, Extended Abstract

Tims H.A. and D.R. Cahill, 1983, OPSEIS seismic recording system, 12th AAPG Annual Convention Proceedings (Volume 1), pages 345-357

Uribe J., L. Rodriguez, P. A. Munoz, R. Parrado, N. Sanabria, 2016, High Density 3D Nodal Seismic Acquisition in Sub Andean Mountains - An Operational Challenge: SEG 87th Annual Meeting, expanded abstract

Wilcox S., 2013, Seismic data recording: US patent 8,547,797

Wilcox S., 2015, Drone support seismic acquisition: E&P Magazine June 2015, 67-69

Acknowledgments

The authors wish to thank their employer Sercel for their help and permission to devote time to the preparation of this paper.